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THE AMERICAN
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VOL. V. ANN ARBOR, AUGUST, 1888. NO. 4.

ORIGINAL ARTICLES.

SOUTH ALBERTA, AND THE CLIMATIC EFFECTS OF THE CHINOOK WIND.

BY C. C. MCCAUL.

Alberta is that part of the Canadian northwest bounded by the 49th parallel of N. latitude—the International Boundary Line—on the south; on the north by the 55° N. latitude; on the east by the 112° 20′ W. longitude, and on the west by the main range of the Rocky Mountains. The district of the Chinook winds—the country of the great cattle and horse ranges—to which I more particularly refer, extends from the southern boundary to the Red Deer River on the north, and from the Rocky Mountains on the west, to say, 140 miles east.

The physical characters of this district are well marked: In the west, abruptly rising from the foothills and prairie plateau, for it is difficult to determine where the one ends and the other begins, we have the grand chain of the Rocky Mountains. Their average elevation may be roughly placed at 5,600 feet, the base level being about 4,300 feet. Many peaks rise much higher: Sheep Mountain, 7,580; Anderson, 8,200; Turtle, 7,000; Crow's Nest, 8,500; Mt. Lefroy, 11,658, etc., etc.

The range looms up in bold and strong relief against the western horizon, a mighty rampart of limestone peaks, whose

bases are clothed with pine, their summits almost naked rock, or covered by perennial snow.

The snow limit may be roughly placed at 6,500 feet, though in sheltered valleys of course it is much lower. Glaciers of hard-packed snow and ice occur in many places.

The rocks are principally palæozoic, Devonian and Carboniferous; the mesozoic rocks are formed in patches. The average width of this part of the range is not more than fifty miles. On their eastern margin the mountains rise precipitously from the foothills to a great height, except where broken by passes to the valleys in the interior. The Livingstone range, which extends from the Middle Fork of the Old Man's river to the southern tributaries of High river, present to the traveller approaching from the prairies one vast unscalable wall of naked limestone, unbroken for fifteen miles save for "The Gap" through which the North Fork of the Old Man makes its way out over the plain. To the west of this main chain is a succession of smaller mountain ranges and valleys.

The foothills extend for about twenty miles east of the mountains, generally bare of trees, but, in spring, soft and green with verdure of innumerable grasses; in summer gay with brilliant masses of the prairie and hill flowers, and in autumn richly tinted with a warm purple heather-like glow.

"The foothills, though they may be regarded structurally as a portion of the mountains, being composed of rocks flexed and disturbed parallel to and contemporaneously with those of the mountains proper, differ much in their general appearance and character from them, and seldom equal even their outer and lower summits in height. They are composed of the cretaceous and Laramie rocks, which further east in nearly horizontal and unbroken sheets form the sub-structure of the great plains."

"The foothill region is characterized by a series of long ridges, or hills arranged more or less definitely in linear series, the positions of which have been determined by zones of harder rock—generally sand-stones. Between these ridges are wide valleys in which the smaller streams course, while the larger rivers having their sources in the mountains generally cut across

nearly at right angles. Though very well marked south of the Old Man river these ridges are there usually rather low, and the prairie may be said to spread up to the very base of the mountains proper." Further north the hills and ridges grow higher and more abrupt, and the wood areas become more considerable. The mean elevation of the foothills is about 4,000 feet.

On the east the foothills merge into the undulations of the prairie plateau, running in a general direction east and west. The mean elevation at the base of the foothills is 3,300 feet, and the plateau slopes gradually to the east, having an elevation at Lethbridge of 2,730 feet, or a fall in forty miles of about 600 feet. The foothills and prairie are covered with thick and luxuriant grasses, comprising numerous species and varieties, and including the well known "buffalo" and "bunch" grasses, which, once the favorite food of the buffalo, are now as eagerly sought after by the cattle that have taken their place.

In sheltered valleys and coulées the grass is, as might be expected, most abundant and luxuriant: here we find the lofty "blue-joint" which often attains a height of six or seven feet. The soil is generally good: a dark vegetable mould of no great depth, overlying a rich brown or gray loam.

The plateau is traversed by swift, clear rivers and streams heading in the mountains, and cutting through the foothills, where they are fed by numerous creeks and rivulets. Their courses are cut away through drift, gravel and rock, far below the level of the plain. The principal rivers, all tributaries of the great Saskatchewan, are St. Mary's, Belly, Waterton (or Kootanie) Old Man, Willow Creek, High River, Sheep Creek, Elbow, Bow and Red Deer. Lakes, in the prairie region are few and small; among the foothills, however, they are more numerous, but never of any extent and of no importance from a climatic point of view.

The district, whose physical features have been thus roughly described, is the celebrated grazing country of South Alberta, where cattle and horses range without shelter winter or summer in the latitude of Labrador.

Without accurate meteorological data it is impossible to give

more than a general description of the climate, but a residence of five years at Fort Macleod on the Old Man river enables me to feel that I can speak competently and fairly accurately as to the general character of the climate of the district. To begin with winter: The first winter month is practically December. Cold spells and snow sometimes occur in November, but as a rule winter does not fairly set in until the latter half of December. Frequently it is mild, even warm, up to Christmas. When the cold really does set in it is not uncommon for the thermometer to go to 20°, 30°, 40°, and even 50° below zero; but this, *as a rule*, lasts no longer than two or three days. Sometimes the severe cold lasts for two, or even three weeks, and during all this time the thermometer never manages to crawl above —20°. The winter lasts until about the middle of February, when it is over to all intents and purposes, but occasional cold snaps may be expected to the end of March. It is characterized by a maximum of bright, still, cloudless days; a scanty snow fall, and frequent and prolonged breaks of warm weather, heralded by the Chinook wind, of which more hereafter. Occasionally a bad snow storm will cover the prairie and hill to a depth of eighteen or twenty inches. This, however, is very exceptional. The winter generally breaks up in February by a grand blow from the west, followed by a period of from one to three weeks of warm, bright weather, which may fairly be called the beginning of spring. Spring, here as elsewhere, is the most variable and capricious season of the year. On the whole it may, perhaps, be described as cold and damp, with frequent rain-falls, varied by bursts of the most gloriously bright warm weather, lasting sometimes a fortnight or three weeks. The earliest spring flowers, the yellow snow-drop (Frittilaria pudica) and so-called crocus (Anemone patens) appear in March; in April follow false indigo (Baptisia tinctoria), shooting-stars (Dodecatheon mædia), and violets of the most heterogeneous hues; while in May the evening primroses (Enotheræ), pentstemons, astragali, letches and lupines, are in their glory.

May is generally fine, warm, and bright; June and the earlier part of July rainy; the remainder of July, August, September,

October, and generally November, warm and very dry. The summer, July to September, is characterized by hot days and cool nights, with very little rain, but the warm, lazy days of autumn, often lasting well into December, are the glory of the year.

The grand characteristic of the climate as a whole, that on which the *weather* hinges, is the Chinook wind. It blows from west to southwest, in varying degrees of strength, from the gentle breeze that just tosses the heads of the daisies and sunflowers, to the howling gale that carries off contributions of chimneys, barrels, shingles, hats, and miscellaneous rubbish to our neighbors in Assinaboia. In winter, the wind is distinctly warm; in summer not so distinctly cool. Its approach is heralded by the massing of dark cumulus clouds about the mountain tops, and a distant wailing and rumbling from the passes of gorges. Its effect in winter is little short of miraculous. When a *real* Chinook blows, the thermometer often rises in a few hours from 20° below to 40° above zero; the snow, which in the morning may have been a foot deep, disappears before night; everything is dripping; but before another night falls all the water is lapped up by the thirsty wind, and the prairie is so dry that a horse's hoofs hardly make an imprint as you take your first welcome canter, after a prolonged and tedious spell of "settin' round the stove."

The following description is from an article by Mr. Ernest Ingersoll in the "Canadian Record of Science": "This wind is marvellous in its effects. To it is due the pleasing dryness of even the deepest gorges and nooks in the rocks in summer, while in winter it clears the plains for hundreds of miles away from the mountains of nearly all the snow—always scanty in amount—with amazing celerity. A northern gale will blow for two or three days, forcing the mercury below zero, and bringing all the wide plains under a foot or two of drifted snow. Cattle, horses and wild game can only huddle in sheltered hollows or hide among the groves along the river banks and hope for better times. All the pasture is covered with a blanket of snow, too deep to let an animal get a bite of grass. Then the wind lulls

and a breeze from the west springs up. It is warm—almost balmy in contrast to the biting eastern or northern snow-gales.

"Near the mountains only a few hours suffice to lick up all the snow, except from the gullies, into which it may have drifted to a great depth. Cattle and horses find the grass exposed, and resume their feeding. The cold has done them no harm, for there has been no wet snow or sleet." It should be added that the grass has not suffered, for the long, dry days of last autumn have cured it, and nature has provided her own hay to feed the herds and flocks through the cold winter months.

Sir Alexander Mackenzie, who explored the country about 1790, in his "Voyages," page 138, when describing the climate of the Peace River and Saskatchewan country, says of these warm westerly winds: "I had already observed at Athabasca that this wind never failed to bring us clear, mild weather, whereas when it blew from the opposite quarter it produced snow. Here it is much more perceptible, for if it blows hard from southwest for four hours a thaw is the consequence, and if the wind is from northeast it brings sleet and snow. To this cause it may be attributed that there is so little snow in this part of the world. These warm winds come off the Pacific Ocean, which cannot in a direct line be very far from us, the distance being so short, that though they pass over mountains covered with snow there is not time for them to cool."

Nine persons out of ten smile incredulously when you describe a "Chinook;" but surely if a scientific explanation of the phenomenon can be added to the personal experience of hundreds, the most doubting Thomas should be convinced.

What are the data? A great, grassy, treeless plain, barren of large lakes or sheets of inland water, rising to an elevation of some 4,000 feet in the foothills of the Rocky mountains, bounded on the west by a lofty barrier of mountain rock, capped with huge masses of ice and snow; beyond the successive mountain ranges and valleys of British Columbia; beyond all, the waters of the Pacific warmed by the genial current—the Kuro Siwa—the Gulf Stream of the Pacific Ocean. A prevailing westerly

wind, blowing over the whole continent of North America, saturated with moisture from its passage across the ocean. There are undoubtedly other special and local causes at work; the sun's action on the treeless prairie, the effect of radiation, etc., etc., should be taken into account, but in the absence of accurate meteorological investigation it is wiser not to consider the secondary causes at all. With the data before us, however, it is not difficult to account in large measure—even to forecast—the general climate of South Alberta.

The principles at work are familiar. Firstly: When ice is changed into water, or water into vapor of water, heat is *absorbed*; when vapor of water is deposited as rain or snow, or water becomes ice, heat is *evolved:* the principle of the *latent heat of water.* Secondly: When air becomes expanded and its moisture further evaporated, a great quantity of heat becomes *latent*; which on condensation of the moisture and compression of the air again becomes sensible. The application of the principle of latent heat to account for meteorological effects is not new.

Lyell, in his Chapter on Vicissitudes of Climate, says: "A large proportion of the sun's heat is employed in the tropics in changing water from the liquid to the gaseous state, being thus absorbed without affecting the thermometer. The moist aërial currents, therefore, which take their rise over the ocean and damp regions of equatorial land, carry a large quantity of latent heat to more northern latitudes, which is set free as the wind cools, and precipitates its vapor in the form of water and snow," and he cites, as examples, the "Föhn" of Switzerland, and the "Sirocco" in Italy. I believe that Tyndall mentions an exactly analogous result, on a smaller scale, in the moisture-laden wind blowing over McGillicuddy Reeks, but writing without access to any library, I am unable to give a more particular reference.

Dr. Geo. M. Dawson, in his report of a survey of the Peace River country, published in the Canadian Geological Survey Reports for 1879, refers the explanation of the Chinook to the same class of phenomena, but dwells more particularly on the doctrine of condensation. He says (p. 77 B.): "The pressure

in the upper regions of the atmosphere being so much less than the lower, a body of air rising from the sea level to the summit of a mountain range must expand, and this, implying molecular work, results in an absorption of heat and consequent cooling. The amount of this cooling has been estimated at about 1° Centigrade for 100 metres of ascent, when the air is dry, but becomes reduced to one-half degree when the temperature has fallen to the dew-point of the atmosphere, etc. When the air descends again on the further side of the mountain range, its condensation leads to a sensible increase of heat equal to 1° Centigrade for each 100 metres."

He then makes the following calculation: "Assuming that the air at sea level is saturated, in crossing the mountains it is raised 6,560 feet, say 2,000 metres, making 10° C. or 18° F. sensible heat latent. Descending to the level of the Peace River country, 2,296 feet, or 700 metres, 13° C. or 23° F. again becomes sensible. The amount of heat lost by the air during its passage across the mountainous region, by radiation and contact with the snowy peaks, cannot be determined."

The article before referred to by Mr. Ernest Ingersoll, on the climate of the Canadian West, goes into the subject in greater detail. After mentioning the prevailing westerly winds, and how they become saturated with moisture from the Pacific, he shows how they produce a cloudy sky and heavy rainfall on the Coast range; he then argues that having deposited part of their moisture on the Coast mountains, and being further robbed of it by the Gold range and Selkirks, they "have lost all their moisture and warmth, and have been rarified by being forced to an average height of seven or eight thousand feet," and concludes, "Hence, when they pass to the Rockies they are dry and cool in summer—dry and very cold in winter," and he then explains the Chinook as follows:

"The air ascending the western side and at the top of the Rockies is cold *because it is losing its moisture* and becoming rarified; the air descending the eastern slope becomes condensed, *picks up moisture* with every part of its descent, and correspondingly develops or *gives up the latent heat* which

invariably accompanies condensation. The Chinook then is a warm, dry wind manufactured on the spot by the condensation of the mountain air as it sweeps down, increasing in density, absorbing moisture, and yielding up its latent heat." (N. B.—The italics are my own.)

If by "*losing its moisture*" Mr. Ingersoll merely means, that the moisture in the air becomes further evaporated, and by "picking up moisture" that the air by becoming condensed makes the moisture more apparent, he is, on the principle of condensation, no doubt, right to a certain extent, but I think this principle alone is quite inadequate to account for the wonderful effect of the Chinook in winter. By his own argument the wind when it reaches the Rocky mountains is "*dry and very cold* in winter." How can a *dry* wind lose its moisture? But passing over this, and admitting the action of the principle in the manner stated by Mr. Ingersoll, this would only account at most for an increased temperature of about 23°. Now when the temperature at Macleod is, say 25° below zero, it may fairly be assumed that the temperature at the summit of the mountains is 10° lower, say —35°. Now comes the "dry and very cold wind," and passing over the mountain tops becomes colder, falling to say their temperature —35°; on descending to the plain the 23° of heat become sensible, and the temperature of the air is raised to —12°. This, however, will not account for the action of the Chinook as described by Mr. Ingersoll. A strong wind, with the temperature 12° below, could by no stretch of imagination be called "balmy," and as a matter of fact would in two or three days do infinitely more harm to cattle and horses than weeks of bright, still weather at a temperature of —25°.

If, however, Mr. Ingersoll wishes his words to be accepted literally, he announces a new theory of latent heat: *losing its moisture*," i. e., changing vapor of water into rain or snow, the air becomes *cold*; and when it "*picks up moisture*," i. e., changes water, ice and snow into vapor of water, it "gives up" or evolves heat; and the wind which has been thus picking up moisture with every part of its descent becomes by the process the *dry*, warm Chinook wind of the foothills and prairies.

I cannot agree with the conclusion that the Chinook is a dry, warm wind manufactured on the spot by the process indicated by Mr. Ingersoll. No! It must be admitted that the wind that blows against the tops of mountains is a moisture-laden wind, whether its moisture be part of its tribute from the Pacific, or has been "picked up" as it travelled up the western slopes of the mountains to their summits on the eastern margin. As I sit on my verandah I can see the huge cumuli gathering in dark masses over Mt. Victoria and Castle Mountain, and depositing their moisture in heavy rains on their snowy summits; and I know that in a couple of hours the heat, that is being evolved by that process, will come down with the western breeze to dry up the mud-puddles left by the northeast rain-storm of last night.

The moisture-laden wind, then, be it warm or cold, blows against the cold mountain summits—its moisture is wrung out of it, like water from a sponge, and falls as snow or rain. This process setting free the latent heat, the wind continues on to the foothills and prairie as a dry, warm wind;—in winter, warm relatively to both prairie and mountain; in summer, warm relatively to the mountain, but warm or cool relatively to the prairie, according as the atmosphere over the prairie is cool or warmer.

But the effects of this wind have much more to do with our climate than merely clearing away the snow in winter, and tempering the air in summer. There are the intermediate periods of spring and autumn. In the autumn, as the cold weather begins to make itself felt in the mountains, and the sources of the streams, the ponds and little lakes begin to freeze, an additional amount of heat is given out, which the kindly west wind hurries down to the plains below to stay the approach of eager winter. Hence our long, warm autumn days—Indian summer really; for this is precisely a similar phenomena to the Indian summer of Ontario and Quebec. In spring, when the sun's rays begin to exert their full strength in melting away the snow and ice from the mountain tops the reverse process occurs—heat is taken up from the surrounding air, and the west wind cannot bring with it its accustomed installment of heat. The wind is more or less cool. Hence our cold spring.

Readings of the Max. and Min. Thers. with the Daily Range of Temperature. Also the Direction of the Wind at 5 A. M., 1 and 8 P. M. Western Standard Time. Calgary, N. W. T.

Day of Month.	May, 1887.						June, 1887.					
	Max. Tem.	Min. Tem.	Range.	Direct. of Wind.			Max. Tem.	Min. Tem.	Range.	Direct. of Wind.		
				5 A.M.	1 P.M.	8 P.M.				5 A.M.	1 P.M.	8 P.M.
1	54.0°	24.6°	29.4°	C	C	NW	53.5°	38.2°	15.3°	C	N	N
2	58.0	24.6	33.4	C	C	C	58.3	34.2	24.1	C	C	C
3	63.0	29.1	33.9	SW	NW	NW	53.0	28.6	24.4	C	C	W
4	57.0	28.1	28.9	NW	W	SW	54.0	39.2	14.8	C	E	NE
5	61.0	27.6	33.4	C	SW	SW	48.0	32.1	15.9	N	N	N
6	58.0	26.6	31.4	C	S	S	51.0	37.2	13.8	N	C	C
7	52.5	31.1	21.4	C	W	W	65.0	36.7	28.3	C	C	C
8	54.0	23.1	30.9	C	SW	SW	68.5	32.7	35.8	C	C	C
9	56.5	24.1	32.4	SW	SW	SE	74.5	38.2	36.3	C	C	C
10	63.5	36.7	26.8	SE	C	C	72.0	44.7	27.3	C	N	N
11	53.0	30.6	22.4	C	C	C	69.0	37.2	31.8	C	C	C
12	51.0	30.6	20.4	C	C	C	52.5	42.2	10.3	C	E	N
13	54.0	34.2	19.8	C	NW	NW	63.5	47.7	15.8	C	C	C
14	48.0	35.2	12.8	NW	NW	C	73.5	44.2	29.3	C	C	C
15	59.0	28.6	30.4	C	C	C	71.0	47.2	23.8	C	C	C
16	71.0	25.6	45.4	C	C	E	67.5	53.7	13.8	C	NW	C
17	83.0	40.7	42.3	C	C	C	64.0	48.2	15.8	W	NW	NW
18	84.0	41.2	42.8	C	C	N	70.5	43.2	27.3	C	NW	NW
19	64.0	34.7	29.3	N	N	N	63.0	41.2	21.8	C	NW	NW
20	41.0	30.6	10.4	E	SE	C	70.0	39.2	30.8	C	C	C
21	58.0	30.6	27.4	C	C	C	77.0	52.7	24.3	C	C	C
22	72.0	39.7	32.3	C	C	NW	84.5	47.2	37.3	C	S	C
23	78.0	44.7	33.3	NW	C	C	77.0	45.7	31.3	NW	C	N
24	79.0	41.7	37.3	C	C	W	53.0	39.7	13.3	C	C	C
25	69.0	41.7	27.3	N	E	C	54.5	43.7	10.8	C	S	SE
26	70.0	46.2	23.8	C	NE	C	53.0	42.7	10.3	NW	NW	NW
27	76.0	45.2	30.8	C	C	W	64.0	40.1	23.9	C	SW	SW
28	77.0	46.2	30.8	W	W	C	69.0	37.0	32.0	C	C	C
29	76.0	37.7	38.3	C	C	C	67.5	50.7	16.8	C	NW	C
30	90.0	40.7	49.3	C	C	W	74.3	39.7	34.6	C	C	C
31	75.1	50.2	24.9	NW	E	NE	....	....	....	....	....	....
Mean	66.8	35.7	31.1	....	....	....	64.5	41.5	23.0	....	....	....

READINGS of the Max. and Min. Thers., with the Daily Range of Temperature. Also the Direction of the Wind at 5 A. M., 1 and 8 P. M., Western Standard Time. Calgary, N. W. T.

Day of Month.	July, 1887.						August, 1887.					
	Max. Tem.	Min. Tem.	Range.	Direct. of Wind. 5 A.M.	1 P.M.	8 P.M.	Max. Tem.	Min. Tem.	Range.	Direct. of Wind. 5 A.M.	1 P.M.	8 P.M.
1	72°.0	46.7	25°.3	C	N	C	74°.0	48°.7	25°.3	C	C	SE
2	77.0	44.7	32.3	C	C	C	78.8	46.7	32.1	W	C	N
3	82.4	48.7	33.7	NW	S	C	60 5	43.2	17.3	N	N	NW
4	79.5	44.7	34.8	C	C	C	69.0	40.2	28.8	W	C	C
5	83.0	49.2	33.8	C	N	N	77.8	44.9	32.9	C	C	C
6	82.3	54.7	27.6	C	N	C	71.0	47.0	24.0	W	NW	N
7	80.0	52.5	27.5	N	SW	C	52.9	44.2	7.8	N	N	N
8	83.8	44.3	39.5	N	C	C	54.0	40.4	13.6	C	C	C
9	84.5	44.2	40.3	C	N	N	72.9	32.2	40.7	SW	N	C
10	66.0	45.3	20.7	E	SE	N	72.9	40.7	32.2	C	C	N
11	57.0	39.4	17.6	C	N	N	72.5	49.2	23.3	C	SE	C
12	67.4	32.7	34.7	N	C	SE	73.0	47.2	25.8	C	E	C
13	78.0	38.2	39.8	C	S	N	73.0	46.7	26.3	C	C	C
14	70.0	34.7	35.3	N	C	C	76.0	48.2	27.8	C	SE	C
15	66.0	47.7	18.3	NW	NW	NW	80.3	45.2	35.1	C	C	C
16	75.4	35.0	40.4	NW	SW	C	79.9	51.7	28.2	W	C	NW
17	75.5	41.2	34.3	W	N	C	80.1	50.2	29.9	C	C	C
18	78.0	40.9	37.1	NW	C	C	79.2	44.7	34.5	W	SE	C
19	80.0	44.2	35.8	C	SE	SE	77.9	51.7	26.2	NW	C	C
20	80.1	50.3	29.8	C	N	NE	68.0	53.7	14.3	N	N	N
21	75.5	51.2	24.3	C	C	C	61.5	48.2	13.3	W	N	C
22	82.6	54.7	27.9	C	C	C	63.5	45.7	17.8	SE	SE	SE
23	71.5	57.2	14.3	C	N	C	58.2	44.9	13.3	C	SE	SE
24	69.0	46.7	22.3	S	S	N	65.0	39.7	25.3	C	SE	SE
25	56.0	47.2	8.8	NW	NW	NW	60.2	46.7	13.5	NW	N	C
26	57.0	47.2	9.8	NW	NW	C	66.3	36.7	29.6	C	S	C
27	50.0	40.2	9.8	N	N	NW	73.5	47.2	26.3	C	C	C
28	65.0	39.7	25.3	NW	C	C	67.0	43.2	23.8	S	S	C
29	78.0	43.5	34.5	NW	C	C	63.5	33.7	29.8	C	C	C
30	78.0	50.7	27.3	NW	C	C	56.0	42.7	13.3	C	C	C
31	80.4	46.7	33.7	NW	C	C	60.0	44.7	15.3	C	SE	C
Mean	73.6	45.3	28 3	....	....	....	68.9	44.8	24.1	....	....	....

READINGS of the Max. and Min. Thers., with the Daily Range of Temperature. Also the Direction of the Wind at 5 A. M., 1 and 8 P. M., Western Standard Time. Calgary, N. W. T.

Day of Month.	November, 1887.						December, 1887.					
	Max Tem.	Min Tem.	Range.	Direct. of Wind.			Max. Tem.	Min Tem.	Range.	Direct. of Wind.		
				5 A.M.	1 P.M.	8 P.M.				5 A.M.	1 P.M.	8 P.M.
1	65.0	34.7	30.3	C	C	NW	12.0	– 3.0	15.0	C	SE	C
2	52.0	25.6	26.4	W	NW	C	5.0	– 6.5	11.5	C	C	N
3	48.0	25.6	22.4	C	SE	C	5.0	–16.5	21.5	NW	C	NW
4	65.0	26.6	38.4	C	C	C	– 6.0	–17.7	11.7	SE	E	SE
5	60.0	26.6	33.4	C	C	C	– 5.0	–11.7	6.7	N	NW	SE
6	36.0	27.6	8.4	NW	C	C	– 4.0	–11.7	7.7	SE	SE	SE
7	48.0	17.6	30.4	C	SW	W	44.0	– 8.5	52.5	SE	SE	W
8	34.0	17.6	16.4	C	C	W	37.0	2.5	34.5	E	E	N
9	57.0	21.6	35.4	S	S	C	4.0	–10.6	14.6	SE	E	E
10	59.0	36.5	22.5	S	W	C	15.0	–11.7	26.7	E	E	C
11	45.0	29.6	15.4	C	C	C	40.0	14.6	25.4	C	C	W
12	48.0	21.6	26.4	NW	W	NW	40.0	24.6	15.4	C	W	NW
13	59.0	22.6	36.4	C	SW	W	31.0	8.5	22.5	C	C	C
14	48.0	23.6	24.4	W	W	NW	43.0	17.0	26.0	C	NW	C
15	36.0	24.6	11.6	W	NW	S	39.0	21.0	18.0	C	C	W
16	30.0	10.5	19.5	NW	N	C	45.0	23.6	21.4	W	W	C
17	46.0	13.6	32.4	W	W	W	47.0	16.6	30.4	W	W	NW
18	44.0	24.7	19.3	W	N	C	35.0	3.0	32.0	NW	N	N
19	59.0	19.6	39.4	C	C	C	9.0	– 9.5	18.5	C	S	C
20	56.0	25.0	31.0	C	N	E	24.0	– 8.5	32.5	C	C	W
21	33.0	10.0	23.0	N	N	NW	44.0	18.6	25.4	W	W	W
22	24.0	1.5	22.5	W	W	SW	48.0	25.0	23.0	C	NW	C
23	32.5	2.5	30.0	C	C	C	36.0	15.6	20.4	W	W	W
24	29.0	11.6	17.4	C	NW	NW	29.0	13.0	16.0	C	C	C
25	1.0	–12.0	13.0	NW	NW	C	7.0	– 7.0	14.0	NW	NW	E
26	–2.0	–24.7	22.7	W	W	W	– 7.0	–15.0	8.0	NW	NW	E
27	6.0	–14.6	20.6	NW	SE	C	– 8.0	–19.3	11.3	SE	SE	SE
28	12.0	– 8.6	20.6	SE	SE	SE	– 6.0	–16.3	10.3	SE	SE	SE
29	7.0	– 0.5	7.5	SE	SE	SE	– 8.0	–12.3	4.3	E	NW	NW
30	16.0	– 6.5	22.5	C	C	C	–10.0	–14.3	4.3	N	N	NW
31	....	....	....	....	....	....	–13.0	–20.5	7.5	S	S	C
Mean...........	38.5	14.5	24.0	....	....	....	18.5	– 0.5	19.0	....	....	....

READINGS of the Max. and Min. Thers., with the Daily Range of Temperature. Also the Direction of the Wind at 5 A. M., 1 and 8 P. M., Western Standard Time. Calgary, N. W. T.

Day of Month.	January, 1888.						February, 1888.					
	Max. Tem.	Min Tem.	Range.	Direct. of Wind.			Max. Tem.	Min Tem.	Range.	Direct. of Wind.		
				5 A.M.	1 P.M.	8 P.M.				5 A.M.	1 P.M.	8 P.M.
1	27.0	−25.7	52.7	C	W	C	33.0	20.0	13.0	NW	NW	NE
2	27.0	− 1.5	28.5	C	C	C	20.0	10.5	9.5	C	S	S
3	13.0	− 8.5	21.5	NE	E	NW	32.0	6.5	25.5	NW	W	C
4	− 5.0	−15.7	10.7	N	N	N	33.0	5.5	27.5	NW	NW	C
5	−11.0	−19.7	8.7	N	N	N	40.0	7.5	32.5	C	NW	W
6	− 4.0	−21.7	17.7	NW	NW	NW	32.0	11.8	20.2	W	N	E
7	7.0	−13.7	20.7	W	W	C	29.6	7.5	22.1	E	E	E
8	8.0	−17.7	25.7	NW	N	C	11.7	− 1.5	13.2	E	E	S
9	17.0	− 3.5	20.5	W	W	SE	33.0	4.5	28.5	NW	NW	NE
10	4.0	− 4.6	8.6	W	S	C	10.0	0.8	9.2	NW	E	E
11	14.0	−13.0	27.0	C	N	NW	10.0	− 7.6	17 6	E	C	C
12	−13.0	−24.7	11.7	NW	NW	NW	9.0	− 8.5	17.5	N	NW	E
13	−12.0	−28.7	16.7	NW	W	NW	1.0	−20.0	21.0	E	E	E
14	− 2.0	−16.7	14.7	NW	W	NW	2.2	−28.7	30.9	SE	SE	C
15	8.0	−17.7	25.7	W	W	NW	46.0	− 0.5	46.5	C	SW	S
16	10.0	− 8.5	18.5	W	W	W	51.0	32.6	18.4	C	SW	S
17	− 8.0	−19.0	11.0	NW	N	N	49.0	41.7	7.3	S	C	S
18	−19.0	−23.7	4.7	N	N	C	46.0	29.5	16.5	C	W	C
19	−16.0	−30.7	14.7	W	W	W	44.0	16.6	27.4	C	C	SW
20	− 3.0	−27.7	24.7	W	W	NW	44.0	26.6	17.4	NW	N	S
21	0.0	−11.7	11.7	E	E	C	41.0	29.6	11.4	C	E	E
22	− 7.0	−25.7	18.7	C	C	E	52.0	29.6	22.4	W	SW	S
23	− 9.0	−23.7	14.7	SE	S	S	40.0	30.6	9.4	NW	W	E
24	− 4.0	−20.7	16.7	C	C	C	38.0	17.6	20.4	N	C	C
25	3.0	−13.7	16.7	SE	SE	W	39.0	25.6	13.4	C	W	NE
26	17.0	− 6.5	23.5	SE	C	C	51.0	22.6	28.4	C	SE	C
27	48.0	13.6	34.4	W	SW	C	44.0	15.0	29.0	C	W	SE
28	47.0	14.6	32.4	C	C	SE	9.0	1.5	7.5	N	C	E
29	42.0	21.6	20.4	C	C	C	1.0	−15.0	16.0	SE	E	NE
30	50.0	18.6	31.4	C	C	NW	....	....	....	....	....	....
31	48.0	29.6	18.4	W	W	SW	....	....	....	....	....	....
Mean........	8.6	−11.2	19.8	....	....	....	30.7	10.7	20.0	....	....	....

For the foregoing table of observations taken at Calgary, N. W. T., I am indebted to the kindness of Mr. Charles Carpmael, the Director of the Dominion Government's Observatory at Toronto.*

MACLEOD, June 9th, 1888.

PROFESSOR CLEVELAND ABBE, OF WASHINGTON.

In the *Popular Science Monthly* for January, 1888, there is an excellent general sketch of Professor Abbe's work, and the present writer thoroughly agrees with the writer of that article in his estimate of the Professor's character and the great importance of his labors to meteorological science in America.

The present sketch is intended to show in more detail the nature of Professor Abbe's labors, and while a short mention is made of his early training (the early dates being taken from the above mentioned article) yet the greater part of this short paper will refer especially to his work in the Signal Service, as his work there has been of vastly more general importance than that accomplished at other times and places.

This sketch, therefore, can be read, supplementary to the one just mentioned, by those who have read that one, and if the present writer can succeed by this short article, in giving somewhat of an idea of Professor Abbe's great service to meteorology to the readers of this JOURNAL the object of the article is attained.

Cleveland Abbe was born December 3, 1838, in New York City. He graduated from the New York Free Academy (now called the college of the City of New York), in 1857, and after teaching school a short time he went to the University of Michigan, where he gave instruction in higher mathemat-

* *Note.*—As the authorities for some of my quotations are not in all instances given, I refer to the following works which have been consulted in the foregoing:

The Reports and Maps of the Canadian Geological Survey for 1879-80; 1885.

Mackenzie's "Voyages."

Lyell's Geology.

Dominion Meteorological Office: Instructions to Observers.

Mr. Ernest Ingersoll's "The Climate of the Canadian West," published in the *Canadian Record of Science*, 1888.

ics, and pursued a course of study under Professor Brünnow.

In 1860 we find him located at Cambridge, where he spent several years assisting Dr. Gould in astronomical work, and in coast survey work. In order to continue his astronomical studies he spent two years (1865–6) at the great observatory of Pulkowa, where he diligently applied himself as student and investigator under Struve. His training in this great institution, where astronomical precision and enthusiasm perhaps reaches its highest point, was of the greatest benefit to him, enabling him to bring this high standard into meteorological work in later years. Here he also obtained a ready knowledge of German and French, which enabled him to read the scientific writings in those languages with a facility that can only come by an every day use of the languages.

Upon his return to America he was employed for a short time at the Naval Observatory at Washington, but on February 1, 1867, he accepted the position of director of the Cincinnati Observatory, entering upon his duties there in June of the same year. In the prospectus of work to be done at this observatory we can see the high ideal inspired by his European studies, and it was unfortunate that he had not the necessary working force at his disposal to carry it out completely.

"Professor Abbe was called to Washington in January, 1871. At that time he was director of the observatory at Cincinnati, and conducting astronomical and meteorological work there. He had started a weather service at Cincinnati in 1868, and carried on the work of investigating and predicting the weather phenomena for two or three years up to the time of his leaving the city. The member of the Cincinnati Chamber of Commerce and other merchants brought the matter to the attention of the National Board of Trade at Richmond in 1869. Out of that grew the present government Weather Bureau, under General Myer, who called Professor Abbe to Washington to make his official predictions."

It is impossible for one not having access to the manuscripts of the Signal Office, to give a correct idea of Professor Abbe's work there during the first ten years, as probably few

outside of a limited scientific circle knew how necessary he was for promoting the growth of the service. The following statement of General Hazen helps us to understand this: "When I came here * * * * Professor Abbe was * * * * * never permitted to do much that his abilities made him competent to do. He was never permitted to put his name to any work which seemed to him and to other persons of the staff, as well as myself, he ought to do, and when I came into the (Signal) office I set him to work." Much of the Professor's work, both before and after 1881, is, however, explained in the Report and Testimony of the Congressional Joint Commission of 1885–86.

During the period from 1871–80 Professor Abbe's work was circumscribed, and although the official duties mentioned below placed him in charge of working divisions, yet I cannot find that he had at any time a computing force at his disposal, by means of which he could produce such memoirs on American meteorology as have appeared for European countries; and he certainly could not have been expected to perform, unaided, the laborious calculations necessary for extended climatological investigation, and especially where much of the necessary data was still in manuscript, and perhaps unreduced: the strictly military system, much of the time, tolerating only one scientist.

We find, however, from the published list of Abbe's writings (in 1880) that he wrote the first edition of the little book entitled, "Suggestions as to the practical use of Weather Maps, Washington, May, 1871"; he prepared the Tri-daily Weather Probabilities for all of the first year (1871), and about one-third of this work for the succeeding years, 1872–1880; of the Monthly Weather Review, he prepared all of the first publications and reorganized it in 1874, and edited about one-third of those issued from 1874 to 1880; of the Bulletin of International Simultaneous Meteorological Observations, he prepared all of the first two months and the necessary organization in 1875, and about one-half of those issued since then up to 1880.

This might be considered enough work for one man to perform in addition to the reading necessary for him to keep

informed concerning the progress in his science; but during this period (1871-80), Professor Abbe published a number of minor scientific papers in various journals; translated for publication several important short memoirs; prepared articles for Appleton's and Johnson's encyclopedias; prepared the "Annual Summary of Progress" for Baird's Record of Science and Industry, for the years 1873-4-5, Mathematics, Astronomy, Geodesy, Terrestrial Physics, Meteorology and Molecular Physics; and for the years 1876-7-8 the Terrestrial Physics and Meteorology; the climatic maps in Walker's Statistical Atlas, 1876; prepared a number of miscellaneous papers for the current Signal Service publications; carried on his private work of cataloguing the works on Meteorology and Earth's Magnetism from the Royal Society's Catalogue; and lastly, he must have devoted a great amount of time to the study of the important memoirs relating to meteorology that have appeared during late years. Holding during most of this period one of the few civil positions in the country, where the incumbent could devote all of his energies to the advancement of meteorology, Professor Abbe accomplished all he was expected to by his immediate superior, and at the same time continued his private study until he should have an opportunity to give the benefit of his extensive reading and experience to those who might seek it, and who desired the advancement of Meteorological Science; especially in America.

This opportunity came with the entrance of General Hazen into the Signal Service as Chief Signal Officer. General Hazen entered upon his duties with but very little knowledge of meteorology as a science or as applied by the Signal Service, but he had that which well supplied the place of a knowledge of the technical details of the Weather Department as it then existed: he had a mind of unusually broad grasp; he sought the counsel of his aids and wished them to have the credit for the work they performed; he recognized the importance of having the advice of specialists and was willing and anxious to receive all the information available on any points in which he could make an improvement in his department.

Such a man readily saw the valuable assistance he could receive from Professor Abbe, and there was at once established between them a cordial feeling of dependence and support.

This brings us to a new period in Professor Abbe's activity, and in order to see what he has accomplished during the time that General Hazen was in charge, we must consult the Chief Signal Officer's Reports for the years 1881–86.

Professor Abbe's first step was a verbal and urgent exposition of the importance of avoiding military centralization by encouraging the establishment of state weather services, and General Hazen at once made this an important part of the new policy of the Signal Service. The management of the correspondence with state officials and the preliminary steps of organization were entrusted to the Professor, who, after a while, finding his other duties occupied so much time, requested that Lieutenant Dunwoody be placed in charge of the matters connected with the State Weather Services, and he still remains in charge. And so while we owe the earlier steps in the formation of State Weather Services to Professor Abbe, yet the rapid growth of the splendid system of State Services which we now find is mostly due to the great interest and activity of Lieut. Dunwoody in this matter; he having visited most of the states in order to urge the formation of services and to assist in person in this work of organization.

One of the next recommendations of Professor Abbe was the establishment of a "Scientific and Study Division," which was formed early in 1881 with the Professor in charge. It was made the duty of this division to undertake such of the work of the office as required special scientific knowledge, to make such recommendations as might increase the efficiency of the service and to keep posted as regards the scientific progress of meteorology in other countries. The personal supervision of this work, and taking the most active part himself, has occupied most of Professor Abbe's time, but still he has devoted much time to the question of improvements in other divisions than his own, and especially in recommending such changes in the tabulated data published by the Signal Office as would meet the wants of

meteorologists, in this and other lands, who had been dependent for years on results published previous to the organization of the Weather Department of the Signal Service.

It was also due mainly to Professor Abbe that a thorough reorganization of the standards of the Signal Service was commenced in 1881, and improvements in reduction tables made.

In the Chief Signal Officer's Report for 1881 there begins an expressed interest in the scientific growth of the service, and Professor Abbe's sub-reports in this and subsequent volumes keep us pretty well posted concerning the actual work done (from a scientific point of view) and particularly the future requirements; the suggestions being valuable not only to the Signal Service itself but also to the working meteorologists and students of physics of our country. Particular mention may be made of the list of proposed studies in meteorology given on pages 1259–60–61 of the report for 1881. This list cannot but be suggestive to the student who is looking for a subject for investigation, and it must impress the meteorologist with Professor Abbe's knowledge of the needs of this science in America.

In the report for 1882 Professor Abbe's work and influence comes out with greater distinctness. The synopsis of his lectures given there is very valuable in that it is the first published collected syllabus of our present knowledge of *Meteorological Instruments and their Use* (so far as the writer is aware). Very few facts are stated, but the brief headings indicate the authorities to be consulted by the student in order to obtain the best knowledge obtainable of the subject, and he can be quite sure that most of the generally important points have been given.

With the report for 1883 Professor Abbe commences a series of annual reports under his own signature and his thorough knowledge of the details of the work carried on under his direction is clearly shown, and his suggestions are of much value.

A slight mention of some of the most important points mentioned in this report will best indicate the thoroughness of the work done, either personally by the Professor or under his supervision. Thermometry: the calibration of Signal Service sub-standard thermometers, establishment of standards

which shall agree with those adopted by the International Bureau of Weights and Measures, comparison of existing S. S. standards with the air thermometer; the question of the standard exposures for thermometers, both as to the height above ground and the best method of exposure. Barometry: desirability of adopting the normal barometer of the International Bureau of Weights and Measures at Paris, as a standard in place of the Kew standard; the advisability of having a normal barometer of the best construction for the Signal Service. The purchase of European portable barometers and their comparison with St. Petersburg and Paris normals in order to bring to America the readings of these standards; the question of the effect of winds on barometer readings. Hygrometry: comparisons of the methods of Schwackhöfer, Edelmann and others, and making of observations of dew-point at Pikes Peak, Colorado Springs and Yuma. Anemometry: the testing of anemometers by means of the rotation apparatus at the Deutsche Seewarte, Hamburg; comparison of anemometers having different exposures both at sea and on land. Rain-gauge: the question of the effects of exposure were studied, and a special series of observations was instituted at Mt. Washington. Standard time: the mounting of a fine standard clock, by means of which the astronomers who furnish time signals for different parts of the country, could have an opportunity of comparing these different signals by means of a common clock; and also by this means a uniform time can be obtained for making simultaneous observations of atmospheric electricity. Continued attention has been given to the subject of reduction of barometer observations to sea level; and also to the tables of altitudes and latitudes and longitudes of stations. Atmospheric electricity: much time was expended in the consideration of the best methods, and the proposed establishment of observing stations at Harvard College and Johns Hopkins University. Rain-band spectroscopy: comparative observations were instituted at Washington, Boston, Buffalo, New Orleans, St. Louis, San Francisco and Pikes Peak. The subject of solar radiation was studied both theoretically and experimentally.

Meteorological bibliography: the compilation of a general catalogue has been carried on with much activity, and assistance secured from well known European meteorologists.

Such miscellaneous questions as variation in rainfall west of the Mississippi river; reduction of International Arctic observations; astronomical observations; river floods; revision of professional papers and proof reading; making systematic lists of recipients of Signal Service publications, etc., have also been under Professor Abbe's supervision.

A much needed work has also been done by Professor Abbe and his assistants in the form of Meteorological Instruction, both by personal lectures at the school at Fort Myer; and by the preparation for publication of original papers, and translations of important foreign writings on meteorological topics, and by their publication rendering accessible to the Signal Service observers away from Washington, some of the methods and deductions of the ablest foreign meteorologists.

In the succeeding reports of Professor Abbe, we find a continuance of the various lines of work just enumerated and many others concerning which the reader must consult the Chief Sig- Officer's Reports; in fact, the Professor's reports given there are about the only résumés we have of the needs and deeds of American Scientific Meteorology, and his remarks on what is, and what ought to be, keep one posted concerning the progress in this country and the position already attained, both here and abroad.

The annoyance of various "local times" and the need of uniform accuracy led Professor Abbe from an early date to urge a general public reform: this culminated in his report of May, 1879, to the American Meteorological Society, and his letter to W. F. Allen, Esq., at the same time, started the important reform that was consummated in October, 1884.

Later "Reports" would seem to indicate that some of the scientific works inaugurated by Professor Abbe have grown to be separate departments in the Signal Service. During the years 1881–86, much of his time was occupied in attending meetings of a "Board of Consultation," in giving lectures on

meteorology to the "officers under instruction," in routine work relating to scientific questions which constantly arise, and the preparation of a text-book on Meteorological Instruments.

As an outside duty Professor Abbe accepted the chair of meteorology in the quite recently organized Corcoran School of Science in Washington, thereby giving an opportunity to the many employees of the Signal Service in that city to supplement their practical knowledge by receiving in a condensed form the freshest ideas of the ablest modern meteorologists.

A very important part of Professor Abbe's work, which we must not overlook, is his early and continued advocacy of Professor Ferrel's theory of the circulation of the winds. As early as 1865–67, and before Ferrel's theories began to attract attention, we find that Abbe was so strongly convinced of their correctness that he was at particular pains to bring them to the notice of, and explain them to, the chief astronomers and meteorologists whom he met in his two years sojourn in Europe. And these theories must have been very strongly impressed on Professor Abbe's mind to have caused him to advocate them to friends of Dovè and at the time when Dovè was considered the greatest of meteorologists, and when his theories were universally accepted. And when the Professor commenced his weather predictions in Cincinnati, he took Professor Ferrel's theory of the circulation of the winds as a guide, and this enabled him to make successful predictions both then, and afterwards, when he assumed charge of the predictions at Washington.

In his pamphlet "Suggestions as to the Practical Use of the Weather Map" (1871), we find Ferrel's theory popularly explained and brought to the attention of meteorological students in this country. It is probable that but few meteorologists, either here or abroad, have a clearer idea of Professor Ferrel's theories than Professor Abbe has obtained by his careful study of that author's writings, as well as from the close personal friendship that has for many years existed between them; this latter enabled him to obtain, by personal intercourse, explanations of

much that has been made somewhat obscure by the brevity of Professor Ferrel's expression.

Professor Abbe has often said that when he thus came to Washington he foresaw that he would be expected to give up all personality and devote himself to the work of elevating the scientific and practical value of the work of the Signal Service, and that although he shrank from giving up his astronomical career, yet a strong conviction of duty overcame this and enabled him, with the encouragement of Henry, Newcomb and others, to work steadily onward. Animated by the determination to do all he could toward placing Meteorology on a sure scientific basis such as we feel underlies astronomy and chemistry, and to contribute to his utmost to applying the laws of meteorology for the benefit of civilization and humanity, he made many sacrifices which a man of less high ideal would have refused to do. Knowing what has been done in the sciences he cultivates, he clearly sees what ought to be done, and his mind was and is, teeming with suggestions and problems of both scientific and practical nature, few of which, however, he can hope to solve single handed. Professor Abbe's singlemindedness is clearly shown in the readiness with which he responds to all requests of scientific workers for his assistance, either in planning new work or in giving them the full benefits of his extensive study. He wishes the accomplishment of the work: *who* does it, he cares not.

Professor Abbe has been elected into scientific societies both at home and abroad. He has been for many years a member "der Österreichischen Gesellsschaft für Meteorologie," and is one of the few corresponding members "der Deutschen meteorologischen Gessellschaft." In this country, in addition to being a member of various societies such as the "Philosophical" of Washington, and the Am. Assoc. Adv. Science, he was received, in 1881, into the National Academy of Sciences. Also, the Regents of the University of Michigan have recently conferred on him the honorary degree of LL. D.

Personally, Professor Abbe is a most agreeable companion, being generous and unselfish to an unusual degree, he is still

in the prime of life and we feel sure that his influencing power and great knowledge of the work in which he has been engaged so long as a pioneer and steady supporter, will still continue for many years to be important factors in the development of meteorology in America.

THE ORGANIZATION OF THE METEOROLOGICAL SERVICE IN SOME OF THE PRINCIPAL COUNTRIES OF EUROPE.

By A. Lawrence Rotch,
Member of the German Meteorological Society, and Fellow of the Royal (London) Meteorological Society.

THE METEOROLOGICAL SERVICE IN SWITZERLAND.

History.—Meteorological observations were made in the last century at various places in Switzerland, and have been partly published in the *Annals of the Central Observatory.* These observations, however, have only a local importance, and are not comparable, owing to the uncertainty as to the quality and exposure of the instruments and the diversity of hours of observation. In 1823 a committee of the Swiss Naturalists' Society was appointed for the purpose of organizing a system of meteorological observations. Good instruments were established at twelve places, and observations made on a uniform plan, but owing to the want of central guidance, for which there were no funds, little good resulted. In 1860 the plan was again discussed by the Swiss Naturalists' Society, and was carried out in 1863 by its permanent meteorological commission, of which Prof. R. Wolf, director of the Federal observatory at Zürich, was for many years the president. The Federal Council assisted the undertaking by a yearly grant—at first 11,000 francs and afterwards 15,000 francs—and the Cantons subscribed towards the publications. In accordance with the resolution of the Vienna Congress, that each country should establish a Government office for the superintendence, collection and publication of the meteorological observations, the commission proposed the establishment of a Central Meteorological Office. This was sanctioned by the Federal Council in 1880, and in 1881 the Swiss Central

Meteorological Office was established under the Federal Department of the Interior. The chief of the meteorological office of the Naturalists' Society was appointed director of the new Institute. At that time there were 75 stations in operation, and not a single observer withdrew from the new organization.

Organization of the System.—The meteorological service of Switzerland is composed mostly of volunteer stations. The official stations are the Cantonal observatories of Geneva, Berne, Neuchâtel and Bâle, the Federal observatory at Zürich, and the meteorological station on the Sentis. The object is to determine the climatic conditions of the country and to issue weather predictions. The results of the observations are discussed by a central office, maintained by the Government, and in doing this particular attention is paid to local peculiarities of climate in their relation to the elevation of the land.

The Central Office.—The Central Office at Zürich, though possessing instruments for occasional investigations and for checking other observations, is mainly an office for the collection, publication and discussion of the observations. It is superintended by a scientific commission appointed by the State, consisting of seven members, which holds one or two meetings a year for the consideration of questions of organization and for preparing the estimates. The stations are managed by the Central Office. The director, or the adjunct, conducts the correspondence, and the latter represents the director in his absence. The director undertakes the management of the financial administration of the Central Office and the stations. The Central Office has not yet a building of its own, but is located temporarily in the director's house. In 1889 it is to be moved to a building which is being erected by the Polytechnic School as a physical and meteorological observatory.

The staff consists of the director (Dr. R. Billwiller) and an adjunct (Dr. J. Maurer), appointed by the Federal Council, and three assistants appointed by the director. The annual budget for the meteorological service is 32,000 francs. Free postage is allowed for the official correspondence of the Central Office and the stations, and the telegrams for the weather reports are free.

The salary of the director is about 5,000 francs, and that of the adjunct 3,000 francs, a year.

The publications of the Central Office and the system of Weather Telegraphy are detailed further on.

The Stations, their Equipment, and Methods of Observation.—Berne and the mountain station on the Sentis are the only complete stations of the 1st order. Geneva and the station on the St. Bernard pass have registering barometers, and tri-hourly temperature observations are made at Geneva.

There are 70 stations of the 2d order, making tri-daily observations of pressure, temperature, humidity, wind, cloud and precipitation; 15 of the 3d order, which observe temperature, precipitation, wind and weather, and 300 rainfall stations, including the preceding, which also record thunder and hail storms.

The Physical and Telluric Observatory at Berne has two sets of instruments by Hasler, registering electrically at intervals of ten minutes and one hour, respectively, the pressure, temperature, relative humidity, wind direction and velocity, and rainfall. For direct readings there is a Wild-Fuess barometer, thermometers, divided to 0.2° and read by lenses, exposed in a large window shelter, together with a metallic maximum and minimum thermometer of Hermann and Pfister, a Six maximum and minimum, a Koppe hygrometer, and the atmometers of Wild and Piche. Ozone observations are made, and the observatory possesses the seismometers of Rossi, Forel, Forster and Hasler.

The Astronomical Observatory at Zürich possesses a set of registering instruments by Hasler, but they are not now in operation. The Sentis station, described by the writer in the JOURNAL, Vol. II, No. 11, has recently been transferred to a building specially erected for the purpose, which was the subject of a separate article in the last number of the JOURNAL.

The 2d order stations have barometers with a cistern one hundred times the area of the tube, to obviate adjustment of the former. They are made by Hermann and Pfister, of Berne, for 120 francs each. The thermometers are partly by Geissler and partly by Fuess. There are at present few maximum and minimum thermometers, the old metallic instruments having been

found unreliable. The Koppe hair hygrometers made by the successors of Hottinger, of Zürich, replace in winter the wet bulb thermometers. The Wild wind-vane and pressure plate is largely used. The new pattern of rain gauge has a turned brass ring with 0.1 sq. m. area, attached to a tin funnel resting in a graduated bottle. The height of the ring above the ground is 1.50 m. The cost of this gauge, as made by Hottinger's successors, is 20 francs. The snow gauge consists of a cylinder 50 cm. high, with an area of 0.05 sq. m. Seven stations have the Campbell-Stokes sunshine recorders.

The inspection of each station and the comparison of its instruments with a Kew standard thermometer and a Fuess standard barometer, by the director and the adjunct, occurs once in three years. The instruments either belong to the observers or are loaned to them, in which case they become their property after three years' use. From 12 to 15 of the observers receive from 50 to 100 francs a year on returning uninterrupted and reliable registers, and the observers on the St. Gotthard and Sentis are paid 300 and 2,000 francs, respectively, but most of them decline remuneration.

The hours of observation are 7 A. M., 1 and 9 P. M. The rainfall stations observe only at 7 A. M. The instructions to the observers are those issued in 1863 by the former meteorological commission of the Naturalists' Society, entitled *Instruktionen für die Beobachter der meteor. Stationen der Schweiz.* Changes made necessary by the decisions of the International Congresses have been communicated to the observers by circulars. The tables used for the reduction of the barometer are Kämtz's with the suppression of one decimal figure; and for the hygrometer, Regnault's tables. The observations are checked at the Central Office, and the partly uncorrected and partly reduced observations are critically examined and the errors corrected by the help of the observations from neighboring stations. The observations are sent to the Central Office as soon as possible after the close of the month, except those of thunder and hail storms, which are reported immediately to the Central Office on postcards.

The original observations are recorded on one schedule, and the reduced observations on another, either by the observer or at the Central Office. The schedules for the original observations provide for the following data, the elements observed at the same hour being arranged in horizontal lines by which it can more easily be seen if an observation of any element has been omitted:

Thermometers (dry, wet, minimum and maximum).
Barometer (attached thermometer and actual reading).
Wind direction and force.
Cloud direction.
Cloudiness.
Character of weather.
Rain gauge.
Hydrometeors (kind and duration).
Remarks.
Hygrometer.
Means of the above for each observation, except sum of precipitation.

The schedules for the reduced observations have the observations at the same hour arranged in vertical columns.

Temperature (tri-daily observations, mean $= \frac{7 + 1 + 9}{3}$, deviation from normal, mininum and maximum).
Barometer (tri-daily observations and mean).
Relative humidity (tri-daily and mean).
Wind direction and force (3 observations).
Cloudiness and precipitation (three observations).
Precipitation (at 7 A. M. of following day).
Weather.
Remarks.

At the foot of the page are spaces for five day means of temperature, with their deviations from the normals; the mean temperature for 19 years and the deviation from it; do. for humidity; do. for cloudiness; do. for precipitation; frequency of each wind and sums of intensity.

The schedules for the rain stations have columns for the state of weather during the morning and afternoon, precipitation

from 7 A. M. to 7 A. M. of the following day, which is summed up for the month.

The thunder-storm post-cards call for the date, time of duration of thunder, time of passage of storm over the station, duration of rain or hail, direction of motion of storm, direction and force of wind, before, during and after the storm, frequency and intensity of electric discharges. Under remarks is to be given the damage by the storm and the amount of rain.

Publications.—The annual volume, *Annalen der Schweiz. meteor. Centralanstalt,* formerly had the title *Schweiz. meteor. Beobachtungen.*

The contents of the twenty-third volume for 1886 is:

A review of the work of the Central Office and its stations.

Hourly readings of pressure, temperature, humidity, wind direction and velocity and three hour rainfalls at Berne.

Temperatures at 4, 7 and 10 A. M., 1, 4, 9 and 12 P. M., and hourly readings (in Appendix) of pressure, wind direction and velocity on the Sentis.

Tri-daily observations of temperature, pressure, humidity, wind, cloudiness, total precipitation and five day temperature means at 15 stations; monthly and annual *résumés* at 87 stations.

In Appendix: Thunderstorm observations with charts, by Mantel; results of the rain measurements, with charts, by Billwiller.

Hourly duration of bright sunshine at seven stations.

Berne publishes also its own observations with their discussion, under the direction of Prof. Forster, in the *Jahrbuch des tellurischen Observatoriums.* The meteorological observation at the Bernoullianum in Bâle, under the direction of Dr. Riggenbach, are reprinted from the *Proceedings* of the Scientific Society of Bâle.

Weather Telegraphy.—The *Daily Weather Bulletin* issued by the Central Office is based upon telegraphic reports from 58 foreign and domestic stations. The former are received from three central offices in a combined dispatch in the international cipher. The dispatch from Hamburg includes the 7 A. M. observation at 7 German stations and 12 in Great Britain, Scandi-

navia, Holland and Russia; that from Vienna at 8 Austrian and 5 Russian stations; and from Rome at 10 Italian stations. The Central Meteorological Bureau in Paris sends a weather synopsis and the isobars to Zürich and Berne. Sixteen Swiss stations report their 7 A. M. and 1 P. M. observations to the Central Office, and 5 also the 9 P. M. observation of the previous evening, in the same manner.

All these data, received at the Central Office between noon and 2:30 P. M. are entered on charts, and the isobars from 5 to 5 mm. drawn. A summary of the weather conditions is next prepared, with the weather predictions for the next day in Switzerland. These deductions can be telegraphed to subscribers between 2 and 3 P. M. at a reduced rate. The predictions are practically the same for all Switzerland, except perhaps a slight change for the northwest portion. Their percentage of success for 1886 at Zürich was 86 for all elements, considering the predictions to have succeeded, partly succeeded or failed, and reckoning one half the partial successes with the successes, the other half with the failures.

The lithographed *Weather Bulletin* appears about 4 P. M. Some 200 copies are printed, and the subscription price is 12 f. annually. The Sunday issue is published on Monday. It is a folio sheet, with a base map and other permanent matter in blue, and the meteorological data, printed from a zinc plate, in black. One page contains a map of Europe with thei sobars at 7 A. M. for each 5 mm., the temperature in figures and the wind and weather indicated in arbitrary symbols for each station. For want of space, four Swiss stations only are represented. The opposite page gives the 7 A. M. observations at 16 Swiss stations, comprising: barometer (actual and reduced to sea-level, except for the mountain stations, when only the former is given); temperature in C.°, wind, weather, remarks, and precipitation in mm. Below are the 1 P. M. observations, at the same stations, of actual barometer and temperature, with their respective changes in the last 24 hours, wind, weather, and remarks; also the amount of sunshine during the previous day at five stations. A general weather summary, with the weather prediction in

German and French, follows, but it is expressly stated that the last is not to be taken as a prophecy, but only as a conjecture based on previous experience. The weather predictions and some of the observations are published by various Swiss newspapers, but none of them reproduce the weather map.

The Central Office, in exchange for the foreign reports, sends the Swiss morning observations and those of the preceding evening at 5 stations to Vienna and Rome about 10 A. M. daily, and the morning and noon observations at 2 high-level stations to Hamburg about 2 P. M.

The Observatory at Berne, on the basis of telegrams from Paris and Zürich, received about 3 P. M., issues a *Bulletin* showing the position of the barometric maxima and minima over Europe and the 7 A. M. and 3 P. M. observations at Berne, with text stating the distribution of pressure over Europe and the weather predictions for the next day for Berne and neighborhood. The *Bulletin* is posted in the town in the afternoon, and its predictions published by the newspapers. The success of these predictions, in 1879, was about 80 per cent., estimated by an unknown method.

CORRESPONDENCE.

TORNADOES AND LOW PRESSURE AREAS.

To the Editors.—I think my letter on this subject in the May number was sufficiently plain; but as I had not seen Mr. Finley's letter before writing, I ask your indulgence in stating a few facts briefly.

1st. Mr. Finley seems to think that I intentionally claimed to be the first one to make *any* mention of the existence of tornadoes in the southeast quadrant of a low area. In my last letter I positively disclaimed any such idea, which would have been exceedingly preposterous considering that this fact has been one of the best known in the meteorology of this country, and repeatedly mentioned for fifteen or sixteen years. Moreover, I re-

ferred, in my first letter in the April number, to a long discussion of this question by Professor Davis in the August, 1884, JOURNAL, in which he advances the view that this fact was noted as early as 1846.

2d. I stated in my last letter that I was familiar with the Signal Office publications, though Mr. Finley strangely ignores this. I have carefully read the two passages referred to by him, and find only glimmerings of this idea in both. It would have been greatly to his advantage if he had been a little more familiar with these publications himself, for they give no uncertain sound on this question, but show, much more clearly than the references he gives to these publications, that this fact became known very early in the history of the Signal Office. Among a host of references, I will give only three or four. In the Annual Report of the Chief Signal Officer for 1873, p. 1093, I find: "The result was a series of violent local storms, or spasmodic atmospheric convulsions, along the whole southern declivity of low barometer." This sentence appears in a long paper upon the tornadoes of May 22, 1873, in Iowa and Illinois. In the Annual Report of the Chief Signal Officer, 1874, p. 356, I find, "the local storms were especially prevalent over regions covered by masses of air flowing north and northeastward toward the general barometric depressions then existing in the northern sections of the country." Again (Annual Rep., 1874, p. 361): "Severe local storms occurred in the southern half of the depression, while its centre was near the eastern portion of Lake Erie, the region of greatest severity being near the Atlantic coast, and including New Jersey, Delaware, Maryland, and the eastern portions of Pennsylvania and Virginia." I am sure no clearer statement of this fact could be made, except perhaps this last one which I will give. In the Annual Report for 1877, p. 381, I find the following: "Tornadoes occurred in the southeast quadrant of this depression" [area of low pressure].

I have given these references simply to show that I could not have claimed that I had made the first note of this fact. Their bearing upon Mr. Finley's claims I leave for others to consider. It seems to me there is a vast distinction between a simple rec-

ognition of such a fact and discussing its importance in tornado theories.

3d. Mr. Finley gives a very interesting fact in the line of the doctrine of chance. As I understand it, he claims that the first edition of Professional Paper No. VII had so many typographical errors it was suppressed, then a new manuscript or revised printed copy was sent to the printer, and a second time he printed southwest for southeast, although no other error appears in the same text. I have had impressed upon me most forcibly the fallibility of type-setters, but this illustration caps the climax. As to the quotation of the paper by Professor Ferrel, I have a letter from him in which he upholds Mr. Finley's use of the words "southwest quadrant." One thing is certainly true, opposing cool northwesterly and warm southwesterly winds, which are the most essential points in Mr. Finley's tornado theories, can in general only be found, *before a tornado,* in the southwest quadrant of a low area.

It is a fact that a statement of the occurrence of tornadoes to the south and southeast of a low area was made fifteen years ago, and was repeated again and again before 1881. It is a fact that the importance of this matter was unpublished, so far as known, up to March, 1884. Professor Davis, in a long series of papers upon tornadoes in *Science,* in 1883 and 1884, does not mention it; and Mr. Finley himself published maps in February, 1884, which had no mention of it. It is true that since March 30, 1884, this fact has been most prominently brought out, and it is safe to say that no theory of tornado action can now stand that does not take serious account of it. It may be remarked, that my views in regard to the bearing of this fact upon tornado formation have not been accepted by orthodox meteorologists, who are trying to weave it in with the old set theories.

H. A. HAZEN.

July 25, 1888.

CURRENT NOTES.

WATERSPOUTS.—Since the publication with the *Pilot Chart* for March of a supplement descriptive of waterspouts off the Atlantic coast of the United States during January and February, many additional reports have been received, and not only from the North Atlantic, but from the Mediterranean Sea and the North Pacific. A few of these reports, notably one received from Captain Wills, British steamship "British Queen," are accompanied by sketches showing the various stages of the formation of the spout; and such sketches are of the greatest interest. Although there is not space enough on the *Chart* itself to quote these reports in full, yet two of them may be referred to very briefly.

On the *Chart* for May there was plotted the track of a cyclonic storm that crossed the Grand Banks on the 10th and 11th of April on a course about E. N. E. The waterspouts referred to below were formed in its southern quadrants, where the warm, moist air drawn in from the region to the westward of the Azores mingled with the cold air brought down from over the ice-fields in the Gulf of St. Lawrence and the cold Labrador current, east of Newfoundland.

April 10, latitude 41° 59′ N., longitude 47° 30′ W., a large waterspout, accompanied by several smaller ones, formed to the southward of the British steamship "Pavonia," Captain McKay, and traveled to the N. E. at the rate of about 30 miles an hour. The vessel's course was changed to avoid it. As it passed, the whirling rush of air was felt on board. The great column of water reached up to a dense, black, low-lying cloud, and was in shape like a huge hour-glass. It was accompanied by a terrific roaring, and the water at its base was churned into a mass of foam, causing such a commotion that it made the great ocean steamship tremble. When off the starboard bow, the spout broke, with vivid lightning, heavy thunder, and a deluge of rain and hail. Many pieces of ice fell on deck; they were irregular in shape, some of them from four to six inches in diameter, looking, as the captain expressed it, as if chopped off a large block.

On the afternoon of the following day, and in a position about 250 miles N. E. from that of the "Pavonia," Captain Wills, of the "British Queen," reports seeing three distinct spouts at the same time—one to the N., one to the S.W., and one about S.S.E. The one observed most carefully commenced with the formation of three small inverted cones, projecting downward from the clouds. These gradually merged into one, which increased rapidly in size, with a white center visible throughout its length, and seemed to grow downward until it reached the surface, where it caused a great commotion. At first its axis was nearly up and down, but soon became very strongly curved to the westward at about the middle of its length, owing, probably, to varying currents of air. Its diameter gradually decreased until it died away in the distance, a fine sinuous line reaching from the clouds to the surface of the water. Ten sketches accompany this very interesting report.—*Pilot Chart for June.*

NOTES ON SOUTHERN LOUISIANA.—There are few, if any, portions of the United States so wonderfully made as southern Louisiana from the Gulf coast to latitude 30° 30′. It is a section of country where the highest temperature has never exceeded 97°, and the lowest rarely falling below 20°, Fahrenheit. Warm southerly breezes prevail almost during the entire year, carrying with them the scent of the tropics, making the nights delightfully cool during the long summers.

It has an average humidity, 72 per cent., summer and winter, and although to the northerner the heat at 90° may seem greater than it really is, yet from a personal experience, there is not that oppressive heat felt here on the hottest days that is felt in the northern and interior portions of the United States.

Thunderstorms are not a rarity in this section, but there are fewer than further inland. The electrical displays are a marvel during a heavy thunderstorm, resembling more the presence of a body of artillery than anything else; the bolts flashing past trees and house-tops in a manner to put to fright a person of but average courage, and a wonder that such a zigzag of fire can keep up for hours without apparent damage fills the thoughts of

the beholder. Of rain in such heavy storms the heaviest that I have seen was four inches in about two hours.

The average annual rainfall is about 56 inches, equally divided between the months, making the monthly average $4\frac{2}{3}$ inches, and proving that the heavy rains are not a frequent occurrence.

The clear days, entirely free from clouds, will not average a third; but the fair days are in excess. The heavy cumulus clouds are seen in magnificence nearly every evening, and are dispelled toward dusk by the winds blowing from the Gulf.

Of the prominent lakes, Pontchartrain, Maurepas, Borgne, Washa, Grand, White, Calcasieu, and Sabine, the former and Calcasieu are probably those most used by residents as resorts. From New Orleans to Pontchartrain is six miles by rail, where the population of the city go by the thousands each evening, and listen to the music of a superb band, and go bathing, or sailing. The waters of this lake are connected with the Gulf by the narrow Rigoletts at the eastern end of the lake.

Probably the most beautiful spot in southern Louisiana is in the vicinity of Morgan City. This city is situated on Tiger Island, and is surrounded by Grand Lake, Flat Lake, Lake Poularde, Bayou Bœuf, and the Atchafalaya River.

Morgan City is beautifully laid out, with wide streets, hard and white, that shed water rapidly. The streets are planted with oak and myrtle trees, and the rich umbrella china tree. The railroad cuts the town in two parts. A great deal of lumber is shipped from this city to Texas, and the shipment of opened oysters in cans to the same State last year amounted to 21,000,000 oysters. From three to five tons of cat-fish are shipped annually to the West from this point, and are caught by line in the surrounding lakes. The hunting and trapping is a sure means of livelihood in this section, also alligator, otter, sea-gull, and other skins, and the plumage of white cranes, the latter now nearly as scarce as the buffalo on the great western plains. The feathers of the white crane of particular value will not number more than fifteen or twenty on each bird. They are a slenderly delicate aigrette plume, so white and airy that if held to the sun they are scarcely visible. These feathers are worth

$400 per pound in the city market, and I am informed that one man shipped two hundred pounds to France during last year.

A ride in the bayou boats is a novelty to the stranger unlike that experienced elsewhere. They have a distinct motion peculiar to themselves, more like the rocking of a cradle than anything else. Slipping through the drawbridge on one of these boats, lake after lake and bayou after bayou presents itself in this lovely island country, the parish (St. Mary's) being scarcely more than a continuation of these wooded islands: passing pontoon bridges (each plantation has one), which seem to float like cobwebs across the stream. A planter owns both sides of these streams, consequently the necessity of having a bridge for his cattle and teams to cross to cultivate the land on either side.

The trees on the Teche are the cypress and oak, moss-covered and aged. Plantation after plantation was passed; rich fields of cane, orchards of melons and oranges, and the shading fig trees; arbors heavy with the finest of wine-producing grapes; pomegranates, plum and peach trees furnished the shade. Out on the flat lands mushrooms grow plentifully, and water-cresses are tangled over the clear streams. In the gardens are all kinds of vegetables, and about the houses the fragrance of the rarest of flowers, blooming in wild profusion. In the magnolia trees mocking-birds were singing, and in the timber, the home of the deer and the haunt of the delicate bird, the hunter was seen ready for his next shot. R. E. Kerkam.

Notes from the Weather Services.—As is known to most of our readers, the weather service labor for New England is carried on by the New England Meteorological Society. We note that the bulletin is published in coöperation with the Astronomical Observatory of Harvard College. In the April bulletin 147 stations reported; in a few cases there were two or more stations in the same place. Eight stations lie just outside the bounds of New England. We regret to see that the Society will not this season continue its special study of thunder-storms. It would now be interesting for some competent person to point out just what additional territory has been conquered in the recent campaign

against thunder-storms, which has cost much labor for the last few years. That the lines of knowledge have been advanced, no one can doubt; but the literature is scattered, and some one of those who have kept up with it should define for us the amount and direction of advance.

If we have not frequently referred to the Colorado Meteorological Association bulletins (of which No. 24 lies before us), it has not been because we have not admired them or the spirit in which the work is carried on. Professor Loud, of Colorado Springs, is the director of observations, and to him is largely due the success of the weather service so far. Thirty-three stations now report, of which eight belong to the Signal Service. We are very glad to see still included the station on Pike's Peak. If, as was reported some time ago, the Signal Service does abandon this extremely interesting station (interesting from the purely scientific rather than the practical point of view), Professor Pickering, or some other appreciative gentleman who has money to be devoted to such a purpose, should entrust Professor Loud with the care of continuing the work there. It could not be left in better hands, and with series of observations devoted directly to scientific ends, observations on Pike's Peak would be of very great importance.

It is very interesting to look over the reports of the Nevada State Weather Service, of which Mr. Charles W. Friend is the director. This service has been created by Mr. Friend under unusual difficulties. It has now full reports from seventeen stations, all of which are at an elevation of over 3,600 feet above the sea, and most of them above 4,000. The highest is Verdi, in Washoe county, 4,895 above the sea, and Carson City, the central station, is 4,630 feet in elevation. It is especially curious to look over Mr. Friend's sheet of precipitations for April,—it is so blank. Thirty-five stations report precipitation; one reports a total fall of 2.95 inches (the maximum), but the most have less than one inch; while in eight there was only a trace too small to measure, or none.

Mr. Friend reports several earthquakes for April. "On the 13th," he says, " a slight earthquake shock was felt at Carson

City at 7:33 P. M., 120th meridian time. The vibration was apparently from southwest to northeast, and the shock was so light as to be observed by only a few people favorably situated to perceive it. On the 28th, at 8:47 P. M., 120th meridian time, another and more violent shock was felt, not only at Carson City, but also throughout the whole of the western and central parts of the State, and also in portions of California. The direction of the vibration was from south to north; and though no damage is reported to have been done in this State, yet the shock was sufficiently severe as to attract general attention. At Reno the shock was felt at 8 hrs. 48 mins. 38 secs. P. M., 120th meridian time; and at Wellington, at 9:55 P. M., two slight shocks occurred in quick succession."

IOWA THUNDER-STORMS IN 1887.—Dr. Fr. Starr reported on this subject to the Davenport Academy of Natural Sciences, and the report was printed in volume five of the proceedings of the academy. The report occupies about twenty pages of the volume; in it are given the details as to individual storms. In general, Dr. Starr says:

"Three kinds of thunder-storms seem to be reported:

"First. Storms, well defined, traveling from the west, or a western quarter, toward an eastern quarter. Time records, properly made, supply data for calculating the rate of progress eastward. These are apparently connected with the general atmospheric circulation of the United States, and occur in the southeast quadrant of a 'low' area.

"Second. Heat storms, local in character; not showing a progressive movement; often unaccompanied by any wind; seldom beginning until well on in the afternoon, or in the evening. They accompany extreme hot weather.

"Third. 'Squalls,' which are well characterized by Dr. Hinrichs in his 'Bulletins' for June and July, 1882. His account has been quoted by others, but may again be copied here for Iowa readers:

"'Our Iowa squalls are as serious as any on the ocean; the wind may be destructive, but it is not lifting nor revolving as it is in the tornado. Roughly speaking, the squall may be likened

to an extended tornado, having its axis parallel to the ground. Here, in Iowa, it generally bursts upon us from the northwest, following the southeast wind; it rolls over and strikes down upon us, usually with abundant precipitation, and soon is succeeded by the same southeast wind which it so abruptly displaced. * * * So far as I have studied them, they come down from the northwest, progressing at the rate of twenty to fifty miles an hour. In Northeastern Iowa, the storm has a tendency to bend up, so as to make the squall more nearly from the west. In like manner, in Southwestern Iowa its front bends westward, and hence blows more nearly from the north. The storm front is fierce in its power along a considerable distance;—twenty to fifty miles, and more, in its front, along the earth, are struck simultaneously. As the great storm-front moves on, it can be traced for 350 miles from northwest to southeast through our State. It is impossible to confound this storm with the tornado, which is fortunately very restricted in its field, mowing a swath of destruction, generally, in a direction corresponding to the line of the squall storm-front, from a southwesterly toward a northeasterly point. The tornado is narrow, local; the squall at a given instant reaches a narrow, long, extended belt of land like a tornado track, but this belt of destruction is carried forward with great velocity so as to gradually sweep over a large part of the State. Again, the squall of summer is radically different from the blizzard of winter. The squall comes, reaches us, and after a few minutes leaves us, moving onward in its general course toward the southeast; the blizzard blows for hours, and even days. In the squall, but a limited amount of air comes down from the northwest, a great roll of cold and dense air falls upon us; in the blizzard, the entire atmosphere, covering several states, is moving as one body toward the southeast.' "

In conclusion Dr. Starr finds that all three kinds of thunderstorms occurred in Iowa in 1887. The "heat-storms" generally came on between 4 P. M. and midnight, but they often have a later installment, which comes in the early morning. The local thunder-storms this year showed but little wind, and the rainfall in many of them was remarkably light. Very little hail

occurred; a novelty in the electric phenomena was the discovery after such storms of dead animals near the barbed-wire fences. Further, when thunder-storms and hail showed any connection with the "low" areas of the United States Signal Service weather map, the state was generally in the southeast quadrant of such an area, and at a considerable distance from the center.

THE CHINOOK WINDS.—Apropos of these winds on which we publish an article elsewhere, the following note of Professor Hazen will be of interest. We clip it from the *Monthly Weather Review* for January of this year:

The term "Chinook" was originally applied to a south or southwesterly wind blowing over Washington Territory and British America from the region formerly inhabited by the Chinook Indians on the banks of the lower Columbia river. The name is now applied to any rather strong southwesterly to northerly wind which is warm and dry, blowing to the east of the Rocky Mountains. Its lower limit, roughly speaking, is at the forty-fourth parallel, and it may extend eastward to Dakota. Its principal characteristic is the power of melting or almost drying up the snow, as frequently no water runs from it. One of the first published notices of it to be found is in the volume of the Canadian Geological Survey, 1879-'80, page 77, by Mr. G. M. Dawson. The following are some of the more recent notes regarding it: *Science*, August 29, 1884, page 166; December 25, 1885, page 556; January 8, 1886, page 33; January 15, 1886, page 55; AMERICAN METEOROLOGICAL JOURNAL, May, 1885, page 18; November, 1886, page 330; December, 1886, page 342; February, 1887, page 467; March, 1887, pages 507 and 516; August, 1887, page 182; September, 1887, page 224.

The following are some extracts from the above writings: Mr. Ingersoll says: "On the plains about Calgary, latitude 51° N., snow disappears rapidly under the influence of the warm, dry winds, sweeping up from the great Utah and Columbia basins, which people there erroneously call Chinook." Mr. G. M. Dawson says: "The Chinook is a strong westerly wind,

becoming at times almost a gale, which blows from the mountains across the plains. It is extremely dry, and, as compared with the general winter temperature, warm." Professor Harrington says: "They are warm, dry, westerly or northerly winds, occurring on the eastern slopes of the mountains of the Northwest, beginning at any hour of the day and continuing from a few hours to several days."

The wind is generally considered by writers to be similar to the "Föhn" of the Alps, which is believed to be caused largely by the fact that an ascension of the air to the top of the mountains on the west side serves to abstract nearly all the moisture, and liberation of latent heat warms it so much that it descends on the east a warm, dry wind. This explanation for the "Chinook," however, will not hold, for the reason that it is felt on the plains where there are no mountain ranges near. The most remarkable circumstance is that a wind from the northwest, which ordinarily brings intense cold, brings great heat. One of the facts developed by Professor Harrington's study of the actual conditions, has been the existence of a well-developed storm or low pressure area to the northward almost without exception. This seems to increase the difficulty in obtaining a true cause for the wind, because, ordinarily, upon the passage of such a low area, the westerly or northwesterly wind, while very dry, is also intensely cold as compared with that just preceding.

In order to investigate the conditions preceding these winds it was decided to take out all the cases occurring since the maps of the International Bulletin were begun. The months from October to March were studied and all the cases having dry and relatively warm winds from west to north at Virginia City and Helena were selected.

Each of these instances was studied in connection with the international chart giving isobars and isotherms north of the equator. The largest number of cases occurred when there was a low area to the northward, extending far into the Pacific; the next largest occurred with a prominent high area in the plateau between the Cascade Range and the Rocky Mountains.

A few cases occurred with the high area a little farther north. The explanation, then, seems to be the prevalence of a low area to the northward, bringing in air along the southern border from the warm and arid plains and not having a reinforcement of cold air from the northward, as there is no high area in that region, but the low area extends far out upon the Pacific. The same result is brought about when the high area is to the southwestward, causing winds from the west, which are warmed in arid plateau regions by winds from the south.

The following table shows the more pronounced of these cases:

Dates of Chinook Winds in Northern Montana.

1877.	1880.	1882.
1. November 15.	19. January 1.	37. February 5.
2. December 8.	20. January 15.	38. February 15.
1878.	21. January 21.	39. February 26.
3. January 10.	22. October 7.	40. March 1.
4. February 11.	23. October 20.	41. March 19.
5. February 18.	24. October 24.	42. March 27.
6. October 22.	25. November 1.	43. October 8-24.
7. March 21.	1881.	44. November 22.
8. December 2.	26. January 4.	45. December 2.
1879.	27. February 2.	46. December 23.
9. January 24.	28. February 22.	1883.
10. February 23.	29. March 1.	47. January 6.
11. February 26.	30. March 25.	48. November 22.
12. March 6.	31. October 7	49. November 6.
13. March 29.	32. October 30.	50. November 29.
14. October 5.	33. November 26.	51. December 16.
15. October 13.	34. December 8.	1884.
16. October 28.	35. December 15.	52. February 24.
17. November 6.	1882.	53. March 17.
18. December 15.	36. January 1-7.	54. March 26-31.

CHINESE VICEROY LI'S PROCLAMATION ON TREE CULTURE.—A proclamation from Li, Viceroy of Chihli, etc., to exhort the people of his province to cultivate trees after approved methods, with the view of securing benefits to the people and the country.

One of the first principles of governing a state is to look into the nature and uses of its land, to ascertain how it may best subserve the benefit of individuals and the purposes of the state. In the province of Chihli the soil of her alluvial plains

is soft and fertile, and this fertility extends to a great depth. Arboriculture is, therefore, rendered so much the more easy and advantageous. But at present in the various prefectures of Chihli, aside from the several species of fruit trees, such as the chestnut, pear, peach, apple, and apricot, other kinds of trees are rarely seen, as the mulberry and the ching tree (a thorny bush) of Yung-p'ing-fu, which is used for making a species of paper, and for medicinal purposes. In consequence of this general lack of tree culture, vast tracts of fertile plains are left barren, presenting a most monotonous and uninviting appearance. In looking for the cause of this treeless barrenness, it is to be found in the high winds which prevail over these northern parts. When trees are newly planted their roots are easily shaken and disturbed, and unless planted to a great depth they can not withstand the wind. Many of the peasants do not understand the loose nature of the surface soil, and, consequently, by not planting their trees to a sufficient depth, or selecting moist, solid ground for planting, they lose their trees, and their labor becomes fruitless. Few of them ever study the principles of arboriculture, and, as a result, they become discouraged by their non-success, and, giving up the industry altogether, they allow the rich alluvial lands to lie unutilized. The viceroy has in recent years given orders for the planting of willow trees along the banks of the various rivers and streams in Chihli, as a prudential measure for strengthening and protecting the embankments.

If successful methods of tree cultivation in salt lands have been found, how much more easy will it be to carry on arboriculture on rich, level plains? Therefore, the authorities of various prefectures, sub-prefectures, and districts of Chihli are hereby instructed that they must procure the necessary seed trees, and inform the people of their respective jurisdictions of the "eight directions of tree plantation" and the "ten benefits to be derived from same," which accompany this proclamation. Having these directions given them, the people may proceed with tree plantation, at first experimentally. Measures should be adopted to encourage the people in this industry, and on

official agents should be sent who, on the pretext of inspecting and reporting the progress of tree cultivation, really disturb and oppress the people. But at the end of every year the people should be required to submit a statement giving the number and kind of trees planted, how many survived, what their present condition is, etc., so that the authorities may reward those who evince the greatest diligence in carrying out the Government's instructions. And should any be guilty of stealing or cutting down other people's trees, such should be summarily apprehended and severely dealt with by the local authorities. The people should all know that the earnest desire of the viceroy in ordering this system of tree cultivation is that another source of obtaining a livelihood may be afforded the peasants; that droughts may be prevented; that river embankments may be strengthened; that the rainfall may be regulated; that the country may be beautified, etc.

The "eight directions" are:

1. On account of the loose nature of the soil near the surface the cold penetrates to a considerable depth and very easily injures the roots. To fortify the roots against injury from cold and other causes a fertilizer should be used in planting trees, this fertilizer to be prepared by burning a mixture of dung with grass, and then adding to it a proportionate quantity of earth. After putting in the fertilizer the roots should be carefully and sufficiently covered.

2. After a tree has been securely planted, a small cumulus of earth should be placed around it, six or seven inches high, and this cumulus should be renewed at the approach of every winter until the end of the third year after planting. In this manner the tree will be unaffected by the wind or cold, and cannot possibly fail to grow. If this is not done the vitalizing moisture in the earth will escape, and the roots will lack their natural necessary nourishment.

3. In places which are exposed to the high winds, trees should be planted at least 3½ feet deep. Without this depth the rich part of the soil will not be reached, and tree planting can not be successful. In the case of the willow and trees of that kind,

their outspreading and dependent branches should be carefully pruned, in order to preserve the nourishment for the trunk and main branches.

4. Where the soil is poor and sterile it should be improved by the introduction of some rich earth, and adding to it some suitable fertilizer.

5. In the case of the oak, elm, willow, mulberry, poplar, cypress, etc., they shed their seeds every year, which, falling into proper ground, will take root and grow into young trees. To prepare the earth for the growth of the seeds, a trough should be dug around each tree, and be filled with water, in order to keep the soil moist.

6. With willow and mulberry trees planting should take place in the spring, when there is rain. In one year's time the cuttings will have taken root. But before planting the young shoots the soil should be well loosened and fertilized, and grafting should take place after the rain. After planting, the graft trees should be well watered every other day.

7. In transplanting trees strict care should be exercised. Every tree has three vertically-projecting roots, which will dry up if exposed to the wind or sun. Wait till there is rain, and then, having dug a small hole by the side of the tree, carefully cut away one of these straight roots. This process should be repeated after half a month, should there be rain; if not, a month must elapse before the second operation. This is to be repeated until the three roots have been cut away. While these roots are being cut, innumerable new rootlets will be thrown out, and these, as soon as the tree is transferred, will quickly take to the earth. In case of there being no rain, however, they should be well watered.

8. In trying to raise trees from the seeds of the mulberry, oak, etc., some fertile spot should be chosen and prepared, and then plant the seeds in the same manner as one plants seeds of grain. The spring is the best time, and when there is rain. In one year's time young trees, one or two feet high, will spring up, and these can be easily transplanted.

The "ten benefits" are:

1. By planting trees along river banks, where the soil is loose and sandy, the banks will increase in height, and the roots, by their numerous ramifications, will bind and strengthen the soil against the pressure of currents and floods.

2. By covering the mountains on the borders with the pine, elm, willow, etc., a large industry in timber will spring up, which will afford abundant material for house building and other purposes.

3. By planting trees about the fields and farms, they will serve to absorb the superfluous moisture and preserve a just equilibrium of "wind and fluid influences."

4. Where there is an abundance of trees rain will be plentiful, and no droughts will occur in spring or summer.

5. An abundance of trees can also ward off epidemics, and where the people dwell closely together more trees ought to be planted, because they will absorb the carbonic acid and other noxious gases.

6. By having an abundance of groves and trees, travelers and families can find rest and shelter in summer under their shade.

7. Trees and forests being plentiful, they will obstruct the free operation of highwaymen and banditti.

8. Extensive forests of trees on the mountains of the remote borders will serve to absorb a great part of the snow when it melts in the spring.

9. The wretchedly poor peasants, by having a number of trees of their own, will derive sufficient fuel for their needs out of the branches, which they can prune away every year with benefit to the trees.

10. The [*] tree and the [*] trees are of two species, the large leafed and the small leafed; and the [*] (Quercus Mongolicus) is also of two species, the red bark and the white bark. These and the oak can afford food to the silk-worm, and in cold mountainous regions, where the silk-worm subsists merely on the leaves of these trees, they weave a cocoon which, when made into silk, is much cheaper and more durable than that made from the cocoon of the mulberry silk-worm.—*U. S. Consular Reports.*

*The Chinese characters are omitted.